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WEED CONTROL STUDIES IN TWO VARIETIES OF PEAS USING VARYING, CONCENTRATIONS OF M C P B AT PRE AND POST EMERGENCE STAGES.

R. R. Singh, S.K. Singh, and R. K. Rajput

Legumes are known to maintain the soil fertility and are considered a good source of protein in the diet. Pea is an important Rabi season, short duration crop, most suited for double cropping in Rotation with either cotton, Jowar, Bajra or Maize. Because of the wider spacing in peas weeds develop rapidly particularly grown under irrigation, and thus weed infestation increases very much and affects the crop adversely. Mechanical methods of weed control are now considered expensive and may not be suitable due to their root pruning effects on the crop, the use of some of the weedicides in proper dose and at proper stage may be of advantage.

Of the several harmonic materials commercially available in the market, MCPB has been proved most selective towards peas, clover and other legumes (Methews—1956 ; Rosher and Sheldrick 1959). Anderson (1953) noted that weeds were controlled better by M. C. P. A (Na salt) than Dinoseb when applied at the rate of $1\frac{1}{4}$ to $1\frac{1}{2}$ oz. a. e. per acre. Hirst (1956) observed a delay in maturity when MCPB was applied to peas at the rate of 20-36 oz. a.e. per acre, while Carpenter and his Coworkers (1956) did not notice any effect on maturity. They however found a non-significant reduction in the yield of few varieties of peas when MCPB (Na salt) was sprayed at 1.5 to 6 lb. per acre at 2-8 leaf stage.

A perusal of the studies made so far reveals that the chemical weed control in peas is quite effective and may be used with advantage. Hence with a view to evolve a suitable method of chemical weed control for peas, an experiment was conducted at B. R. College, Agricultural Research Station, Bichpuri in the Rabi season of 1959-60, using 0.75. 1.5, and 3.0 lb. of MCPB a. e. per acre at per and post emergence stages. The results obtained from this study are described and discussed in this paper.

Experimental Procedure

The experiment was laid out in complex Randomised block Design with 16 treatment combinations consisting of two varieties of Peas (Local and T163) ; two stages of weedicidal application (pre and post emergence); three concentrations of the chemi-

cal (0.75 lb., 1.5 lb and 3.0 lb a.e. per acre) ; and one hand weeding and one control. The treatments were replicated three times. The commereial preparation 'Tropotox' (containing 40% MCPB as sodium salt of 2-methyl -4. chlorophenoxy butyric acid) was used as spray. The quantity of the chemical was calculated separately for different concentrations and sprayed with the help of a Knap sack sprayer. The water used for the dilution was 60 gallons per acre. The pre-emergencc spray was made only a day after sowing of the crop and the post emergence after 60 days of sowing. The plots which were to receive hand weeding treatment were weeded with the help of Khurpi (a tool used for weeding) after 60 days of sowing. The experimental field was fertilized just before the sowing of the crop with superphosphate applied at the rate of 40 lb. P_2O_5 per acre ; which was drilled in the furrows. The seed rate of the two varieties was kept 30 seers per acre and the sowing was done in furrows $1\frac{1}{2}'$ apart opened by a deshi plough.

Results and Discussion.

The common weeds competing with the pea crop were Krishna neel (*Anagalis arvensis*), Piazi (*Asphodelus tenutifolius*), Akri (*Vicia hirsuta*), Bathua (*Chenopodium album*) and Senji (*Melilotus spp.*) From the studies made on the weed density it was noted that weed kill was better at post emergence stage than at pre emergence. Increasing concentrations of chemical were directly proportional to the per cent weed kill (Table 1.) Sexmith et al (1956); Reynolds, Proctor and Hind (1956) have also reported excellent weed control in peas with post emergence application of MCPA. The findings of Hirst et al (1956), Carpenter and Soundry (1954) confirms that weeds were effectively controlled in peas by MCPB when applied at the rates 1.0 lb. to 3.0 lb a. e. per acre.

Table 1

Percent Weed kill after one month of spraying.

Weed species	Concentrations of chemical at pre emergence stage.			Concentrations of chemical at post emergence stage.		
	0.75 lb	1.50 lb	3.00 lb	0.75 lb	1.50 lb	3.00 lb
Anagalis arvensis.	50.4	61.2	71.6	60.9	68.9	78.3
Asphodelus tenuifolius.	28.8	48.2	55.9	64.8	81.2	88.2
Vicia hirsuta.	33.6	56.4	58.2	60.5	69.3	97.7
Melilotus spp.	10.7	12.6	36.8	69.2	71.5	77.5
Chenopodium album	51.6	62.9	63.7	31.9	60.4	69.8
Others.	19.2	40.6	53.0	45.2	76.0	87.5

In Table 2 variations in yield and yield contributing factors as affected by different treatments are given.

Table 2

Treatments.	Grain yield per acre. (Mds.)	Straw yield per acre. (Mds.)	Grain yield per plant. (gms.)	Straw yield per plant. (gms.)	No. of pods per (plant)	No. of grains per pod	1000 seed wt. (gms.)
1	2	3	4	5	6	7	8
Varieties.							
Local	12.08	17.9	7.4	8.71	12.05	3.72	181.9
T 163	12.02	21.4	4.1	8.97	9.96	3.62	226.7
C. D. at 5%	Non-	2.9		Non Significant			7.4
C. D. at 1%	Sig.	3.9					10.07
Stages :							
Pre emergence.	11.5	19.17	6.91	8.66	10.81	3.59	205.7
Post emergence.	13.4	21.70	7.44	9.37	11.1	3.64	200.4
C. D. at 5%	1.82	Non-	.....	Non	Significant	.....	
C. D. at 1%	2.46	Sig.					
Concentrations :							
0.75 lb	11.95	19.5	8.01	9.93	12.02	3.64	208.7
1.50 lb	13.55	21.5	6.76	8.18	9.69	3.63	106.0
3.00 lb.	12.02	20.2	6.76	8.95	11.34	3.70	194.5
C. D. at 5%	.....	.....	Non Significant	.....			10.83
C. D. at 1%							14.63
Chemical weeding	12.51	20.43	7.98	9.00	10.99	3.61	203.1
Hand weeding.	10.73	17.40	7.93	8.93	13.11	3.70	219.6
C. D. at 5%	..	.....	Non Significant	.....			
C. D. at 1%							
Hand weeding	10.73	17.40	7.98	8.93	13.11	3.70	219.6
Control	10.66	17.38	6.96	7.66	8.88	3.60	193.1
C. D. at 5%	.....	.....	Non. Significant	.....	.....	.....	15.3
C. D. at 1%							20.7

A perusal of the above table reveals that grain yield per acre under post emergence treatment was significantly superior to grain yield in pre emergence treatment. Similarly straw yield of variety T163 was significantly superior to the straw yield of local variety. The differences in rest of the treatments could not vary significantly. Amongst yield contributing factors, variations in 1000 seed weight only, as influenced by different treatments under study except for stages of chemical spray, were statistically significant.

Variety T163 was definitely better than the local variety with respect to

quality as determined by 1000 grain weight. Mehta (1955) has reported better performance of T163 with regard to growth, yield and quality than local.

The significant difference in grain yield of post and pre-emergence treated plots may be attributed to all round better improvement in yield contributing factors with the former than with the latter treatment. The extent of weed control was also better in post emergence than in pre-emergence plots. Sexmith et al (1956) ; Reynolds Proctor and Hind (1953) ; have also reported excellent weed control in peas with post emergence application of MCPB, Dinoseb and MCPA.

The review work on Chemical weed control aspects in peas indicates that the concentrations from 0.5 to 6.0 lb a. e. of MCPA have been used in the past and that the most successful results have been obtained with 1.0 to 3.0 lb a. e. per acre of this chemical depending on the climatic, edaphic and crop growth conditions (Hirst et al, 1956 ; and Carpenter and Soundry 1954). In the present investigation application of 1.5 lb of MCPB appears to give the best results ; although the differences were statistically non-significant. From quality point of view also 1.5 lb application gave very satisfactory results. The results of Carpenter and Soundry (1954) also suggest a dose of 1.5 lb of MCPB for better grain weight of Peas.

Summary and conclusion

Varietal response of Peas to different weedicidal treatments was studied during the Rabi season of1959-60 at B. R. College, Agricultural Research Station Bichpuri Agra. The treatments consisted of (i) two varieties of peas (ii) two stages of weedicidal spray and (iii) three concentrations of weedicides. One hand weeding and one control treatments were also included. In all there were 16 treatment combinations which wer e replicated thrice in a randomised block design. The results show that :

(1) Varietal response to MCPB application was nonsignificant ; the weedicidal effect on yield and quality of the two varieties were identical.

(2) Post emergence applications, appear to give promising results. When the chemical was sprayed at this stage better weed kill was obtained as compared to that noted for pre-emergence ; grain produce of the pea crop was also improved markedly with the post emergence treatment.

(3) The effects of increasing levels in the concentrations on yield factors were statistically non-significant. But on the basis of averages, however, 1.5 lb rate of MCPB appears to be the better dose for peas. Weeds were also controlled with a greater efficiency with this dose.

(4) A comparison between hand and chemical weeding does not reveal any significant difference in yield and other characters. Weeded plots were better for yield as compared to control plots.

For efficient weed control in peas, chemical method of weed control may be

adopted and the application of MCPB at post emergence stage at the rate of 1.5 lb a. e. per acre may be used with success.

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EFFECT OF IRRIGATION WATER OF VARYING SALINITY ON FIELD CROPS.

(Part I)

R. C. Mandal & R. R. Singh

Water-table in the semi-arid tracts of north-western India is fairly deep and the wells, very often, yield brackish water (containing soluble salts, chiefly of sodium) and it is very harmful to plant growth and in due course may render the soil quite unproductive. Foster (1953) observed that less salt tolerent plants like pea, berseem could only stand a salt concentration in irrigation water ranging at 0 to 675 ppm. ($\frac{1}{2}$ to 1 gm. Nacl/litre) whereas relatively more tolerent plants as barley might stand concentrations from 2000 to 3000 ppm.

At Bichpuri Farm, Agra, surface well water (W_1) and deep-well water (W_2) showed salt content 845 ppm. and 1430 ppm respectively, the latter was saline having more dissolved salts which could result in injury to crops by continuous use depending upon their tolerence. During rabi 1956-57, an experiment was carried out on field crops based on randomised design to test the relative tolerence and comparative performance of two cereals (wheat and Barley) and of two legumes (pea and berseem).

The data on growth and yield of the crops under varying conditions of irrigation water are given in table I and table II.

Table I

Mean yield of grain plant, yield of straw/plant, no. of spikes or pods/plant, wt. of 1000 seeds, no. of tillers or branches and height of mainshoot.

Treatments		grain yield (gms/plant.)	Yield of straw (gms/plant.)	No of spikes or pods/ac.	Wt. of 1000 seeds (gm.)	No. of tillers or branches per plant.	Height of main shoot. (inches)
Wheat	W_1	24.76	42.41	10.22	41.82	10.22	57.40
	W_2	24.30	45.00	11.00	40.25	11.00	57.30
Barley	W_1	44.16	62.30	10.72	50.70	10.72	36.54
	W_2	43.16	64.00	11.60	49.10	11.60	40.11
Pea	W_1	50.60	57.00	32.40	32.40	11.25	69.33
	W_2	48.40	46.80	30.00	30.00	10.08	66.58

Table II

Mean yield of grain in mds/ac. and straw of green fodder in mds/acre as influenced by waters of varying salt content.

Treatment		Grain yield in mds/ac.	Yield of straw or berseem fodder in mds/ac.
Wheat	W_1	30.60	68.12
	W_2	31.25	68.30
Barley	W_1	34.70	59.37
	W_2	34.30	68.15
Pea	W_1	29.37	82.97
	W_2	27.85	80.70
Berseem	W_1		836.02 C. Dat 5%=4.2
	W_2		659.40 1%=7.56

As regards growth measured in terms of height, dry weight, or branching at successive stages, it was observed that wheat and barley were not affected whereas pea and berseem showed depression though not significantly. The grain and straw yields of wheat, barley and pea were not affected by the more saline water of the tube well, but the yield of berseem (green fodder) was significantly reduced.

Conductivity of soil, where these crops were raised, was measured before and after irrigation which is tabulated below along with the conductivity of irrigation water.

Water and Soil Sample	Electrical Conductivity (E. C.)	Salt content parts per million (ppm.)
Well water (W_1)	1.3	845
Tube well water (W_2)	2.2	1430
Soil sample (before Irrigation)	3.4	2210
Soil Sample after irrigation with W_2		
(a) Wheat	3.8	2470
(b) Barley	3.7	2405
(c) Pea	3.6	2340
(d) Berseem	6.5	4225

Increasing number of irrigation (9 in berseem, compared to 3 in remaining crops) results in accumulation of salts in the soil and depressed crop growth as well as its yield.

It is, therefore, concluded that increasing number of irrigation of deep tube-well water (salt content 1430 ppm.) results in accumulation of salts in the soil and adversely affects the crop growth. Legumes like berseem or pea are more sensitive as compared to the cereals like barley and wheat.

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EFFECT OF SOURCE, PLANTING TIME AND PLANT REGULATOR CONCENTRATIONS ON SEMI-HARDWOOD CUTTINGS OF SWEET LIME (*CITRUS LIMETTIOIDES* TANAKA).

A.K. Koul Muthu and S. M. Singh

Realising the importance of propagating sweet lime by cuttings, some experiments have been carried out in recent years to study the effect of important factors on the performance of these cuttings (1, 2, 5, 7). The results have been quite variable and indicative of the need for more research work for standardising the technique for commercial adoption.

The performance of the cuttings depends to a very great extent on the time of planting. Singh (6) working with kagzi lime softwood cuttings found that rainy season was far better than spring. Even within the same season the rooting potential of cuttings diminishes with the hardening of source shoots (8), whereas their capacity to survive improves with such a hardening. The effect of opposing trend in survival and rooting potential of cuttings of different vigour gets still more complicated because of the intervention of weather which changes with variations in planting time. The vigour of the source shoots and the rooting of their cutting have been found to be directly related (9) and there is great variation in the response of these cuttings to plant regulator treatments.

This paper describes the results of an experiment conducted to study the effect of source, planting time and concentrations of indole-3-butyric acid on semi-hardwood cuttings of sweet lime which have been found to be far superior to hardwood ones (2).

Materials and Methods

Semi-hardwood cuttings of sweet lime for this experiment were taken from 10 year old bearing trees and 2 year old nursery plants, the latter (mother plants) having being raised from cuttings obtained from the former (grand mother trees). About 9" long cuttings having brownish streaks on green surface were prepared by removing all the leaves. They were treated with 0, 500, 1000 and 2000 p. p.m. indole-3-butyric acid (IBA) in 50 % alcohol by quick dip method (4). They were planted in field at an inclination of about 75° towards south on 26th of each month from July to September 1959 and finally recorded on 4th March, 1960.

The design of layout was randomised block with four replications. The unit plot consisted of a row of 17 cuttings planted at a distance of 1 foot each way. Two of these cuttings on either side formed border, 10 were reserved for periodical observations on shoot growth and final recording of all characters, and 5 from one side were used for the study of progress in rooting. In addition to 24 such plots in which the treatment combinations were randomized there were 2 guard rows on either side giving a border of 1 cutting alround a block.

Results

The performance of cuttings was highly influenced by the date of planting during the rainy season. Rooting, sprouting, survival and establishment of cuttings were the best when they were planted on July 26 (Table I). By delaying the planting to August and September the success was reduced to about half to one third in these respects. The later two dates, however, did not differ much in their effects on these cuttings.

Table I

Effect of Planting date, source of cuttings, and concentration of indole-3-butyric acid on rooting, sprouting, survival and establishment of cuttings.

Treatment	Per cent rooted	Per cent sprouted	Per cent survived	Per cent established
Date of planting				
July 26	81·3	66.6	77.5	66.6
August 26	58.4	42.2	43.1	36.3
September 26	50.9	40.9	61.3	38.4
C D. at 5%	6.80	7.60	—	7.24
C.D. at 1%	9.01	10.07	9.27	9.59
Source				
Bearing trees	56.7	39.6	46.0	37.5
Young plants	70.4	60.2	75.2	56.7
C.D.at 1%	7.34	8.21	7.57	7.84
Concentration of JBA				
0 p.p.m.	57,5	47.5	64.6	46.3
500 p.p.m.	58.3	49.2	64.6	47·1
1000 p.p.m.	62.5	48.3	52,1	42.9
2000 p.p.m.	75.8	54.6	61.3	52.1
C.D. at 5%	7.80	Not	8.88	Not
C.D. at 1%	10.33	significant	11. 76	significant

The source from which the cuttings were taken also exercised considerable influence on their performance. The cuttings from young nursery plants did far better than those from bearing trees from which the former had been raised vegetatively.

The effect of concentration of IBA on the semi-hardwood cuttings of sweet lime was not much marked. There was practically no difference in the performance of the cuttings upto 1000 p. p. m., but under 2000 p. p. m. the results were, on the whole, better.

The growth of roots and shoots was the best when the cuttings were planted on July 26 (Table II). There was not much difference in the various root and shoot characters in the plantings done in August and September, but in both cases they were markedly inferior to the first planting date. Cuttings from young nursery plants were far batter than those from older trees in all these respects. The effect of IBA upto 1000 p. p. m. was not marked on these characters but 2000 p. p.m. improved the growth of roots and shoots.

Table II

Effect of planting date, source of cuttings and concentration of indole 3-butyric acid on various root and shoot characters.

Treatment	No. of roots per cutting	Length of longest root in m. m.	No. of sprouts per cutting	Length of longest sprout in m. m.	No. of leaves per cutting
Date of planting :					
July 26	6.46	126.5	2.92	149.8	27.0
August 26	3.48	63.1	2.33	69.3	10.6
September 26	2.94	61.5	2.65	61.2	10.5
C. D. at 5%	0.184	17.80	0.242	17.16	4.16
C. D. at 1%	0.252	23.79	0.321	22.76	5.51
Source :					
Bearing trees	3.71	63.5	2.43	71.9	11.5
Young plants	4.75	103.9	2.83	114.9	20.6
C. D. at 1%	0.167	19.56	0.260	18.36	4.50
Concentration of IBA :					
0 p.p.m.	3.75	76.7	2.49	82.8	13.1
500 p. p. m.	4.49	82.6	2.70	92.4	17.3
1000 p. p. m.	3.85	80.4	2.39	87.2	14.3
2000 p. p. m,	5.09	95.1	2.94	111.3	19.5
C. D. at 5%	0.246	Not	0.280	19.76	Not
C. D. at 1%	0.326	significant	0.370	—	significant

The effect of date of planting on the two types of cuttings was very interesting. When the planting was done on July 26, there was practically no difference in the rooting, sprouting, survival and establishment of the cuttings of the two sources (Table III). Delay in planting caused a reduction in the success in both the sources but it was much more marked in the case of cuttings from the bearing trees, whereas the cuttings from young plants did well even on later dates.

Table III

Performance of the cuttings of two sources planted on different dates.

Source	Date	Per cent rooted	Per cent sprouted	Per cent survived	Per cent established.
Bearing trees	July 26	81.3	64.4	75.0	64.4
	August 26	46.9	27.5	25.6	22.5
	September 26	41.3	26.9	37.5	25.6
Young plants	July 26	81.3	68.8	80.0	68.8
	August 26	70.0	56.9	60.6	50.0
	September 26	60.6	55.0	85.0	51.2
	C. D. at 5%	9.62	10.74	9.90	10.24
	C. D. at 1%	12.74	14.23	13.12	13.57

The cuttings from the two sources reacted differently to the treatment with IBA (Table IV). Those from bearing trees did not benefit at all from the plant regulator upto 2000 p. p. m., but the performance of cuttings from young plants improved with increase in concentration with the result that the best results were obtained at the highest concentration of 2000 p. p. m. tried in this experiment.

Table IV

Response of the cuttings of the two source to variations in concentration of indole-3-butyric acid.

Source	Concentration	per cent rooted	Per cent sprouted	Per cent survived	Per cent established
Bearing trees	0 p. p. m.	57.5	45.8	51.6	44.2
	500 p. p. m.	49.2	40.0	49.2	40.0
	1000 p. p. m.	41.7	31.7	31.7	26.7
	2000 p. p. m.	69.2	40.8	51.6	39.2

	0 p. p. m.	57.5	49.2	79.2	48.3
	500 p. p. m.	67.5	58.3	80.0	54.2
Young	1000 p. p. m.	75.0	65.0	72.5	59.2
plants	2000 p. p. m.	82.5	68.3	70.8	65.0
C. D. at 5%		11.10	12.40	Not	11.82
C. D. at 1%		14.70	16.43	significant	15.66

DISCUSSION

The findings of this experiment have shown that the performance of semi-hardwood cuttings of sweet lime was the best when they were planted on July 26. When the cuttings were planted in the last week of August and September, there was a marked reduction in their performance in all respects including growth of roots and shoots. The superiority of July planting was mainly due to favourable weather with high humidity and frequent rains and also because of very active phase of the growth of mother plants indicating greater vegetative vigour. Singh (6) working with kagzi lime softwood cuttings found similar results with respect to time of plan,ting and Singh Garner and Hatcher (8)found that rooting of apple softwood cuttings declined with hardening of source shoots as the season advanced.

The cuttings taken from young nursery plants were much better than those from bearing trees in all respects. The chief factor responsible for this difference appears to lie in the vigour of mother plants. Young plants being juvenile and more vigorous are endowed with greater rooting potential than bearing trees. These results are thus in conformity with the findings of Singh, Garner and Hatcher (9) who found a direct relationship between the vigour of the source shoots and rooting of apple leaf-bud cuttings. Vigour is opposed to ripeness gnd advancement in age results in decreased rooting (2, 3).

When the cuttings were planted in the last week of July, the difference between the two sources was not much marked and in both the cases results were highly satisfactory. This showed that when the conditions were very favourable, the age of the mother plants did not matter much in a plant like sweet lime which grows vigorously even in fruiting phase. With dalay in planting the weather conditions became less favourable which increased the difference between the two sources showing the superiority of better source.

Treatment of cuttings with 2000 p.p.m. IBA improved the performance of cuttings in comparison to lower concentrations including control. Hatcher and Garner (4) found that IBA at 0.5 mg. per ml. applied by the quick dip method proved beneficial for apple and plum cuttings. Jauhari and Rahman (5) reported 37.5% rooting when ringed cuttings of sweet lime were treated with 200 p.p.m. NAA. Bhambota (1) working on sweet lime cuttings reported an accelerated and more

vigorous rooting at 4000 p.p.m. when the cuttings were treated with NAA, IAA and IPA in talcum powder.

It was very interesting to find that the cuttings from bearing trees did not benefit from the plant regulator treatment upto the highest concentration tried in this experiment, whereas those from young plants showed significant improvement in their performance with increase in concentration. It appears that the cuttings from older trees need still higher concentration and perhaps the performance of the cuttings from young plants also would improve with concentrations higher than those tried in this experiment.

SUMMARY

An experiment on the effect of planting date, source of cutting and concentration of indole-3-butyric acid on sweet lime semi-hardwood cuttings is described.

Planting of cuttings in the last week of July gave the best results in all respects including growth of roots and shoots (81.3% rooting and 66.6% establishment). On this date there was not much difference in the performance of the cuttings taken from young plants and bearing trees. When the planting was delayed to August and September, the success with cuttings from old trees was markedly reduced whereas the cuttings from young plants did well even on these dates.

The cuttings from bearing trees did not benefit at all from the treatment with indole-3-butyric acid upto 2000 p.p.m. applied by the concentrated dip method, but the performance of those from young plants improved with an increase in the concentration and consequently the best result was obtained at the highest concentration (2000 p. p. m.) tried in this experiment.

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EFFECT OF MEDIA AND CONCENTRATIONS OF PLANTREGULATORS ON AIR LAYERING IN MANGO (*MANGIFERA INDICA L.*)

H. N. Tripathi, R. G. Maiti and S. M. Singh.

In recent years the use of standardized rootstocks of varying vigour has brought a great improvement in the cultivation of apples. Similar rootstocks are desirable in case of mango also. The uniformity of standard rootstocks can be perpetuated either through nucellar seedlings or propagation by rootage. In India, unfortunately, the polyembryonic varieties of mango have been found to retain their character only when they are grown in some limited parts of the conutry ; and the attempts for rooting of mango cuttings have not yielded encouraging results (7).

In air layering, however, Thakurta and Dutt (7) achieved considerable success by using branches of 2-3 years old mango plants and treating them with plant regulators. Since such young plants can give only limited number of layers, Singh (6) tried 20 years old trees of several varieties. He obtained good results with the help of plant regulator treatments.

Choice of rooting media in air layering also varies widely with different workers. Roy (5) recommended a special soil mixture for litchi while Singh (6) used sphagnum moss for mango and Bajpai and Chand (1) a mixture of leaf mould and saw dust for kagzi lime.

In view of the above, it was thought desirable to test the efficacy of different concentrations of plant regulators in conjunction with various rooting media on Bombay Green mango, a variety which has been found to do well under the local conditions. Besides serving as roostocks, the rooted layers of this variety can also be used for orchard plantation.

Methods and Materials.

In this experiment 0, 1 and 2 per cent concentrations of each of naphthaleneacetic acid (NAA) and indole-3-butyric-acid (IBA) were tried along with two rooting media, *i.e.* sphagnum moss and soil mixture composed of equal volume of clay and sieved leaf mould. Thus there were 12 treatment combinations (2 plant regulators x 3 concentrations x 2 rooting media). The experiment was laid out in randomised block design with four replications each on one 20 years old Bombay Green mango tree of comparable vigour. A group of ten layers on each tree was considered to be a plot.

The layering operation was done in the third week of July on 3 years old shoots in view of the findings of Dubey, Maiti and Singh (2). A ring of bark about 4 cm. long was removed from a place 50 to 60 cm. below the growing tip. After rubbing off the cambium completely, the ringed places were treated with respective plant regulators prepared in lanolin. They were then covered with the rooting medium and wrapped with gunny pieces. A 9″ × 9″ piece of 500 gauge polythene film, which allows gas exchange but checks evaporation, was placed around each layer which was finally tied firmly at both ends with strings.

Results.

For calculating the percentage of success only those layers that were alive at separation and had rooted were taken into account but the percentage of rooting and the number of roots per layer were obtained from all the rooted layers whether alive or dead. It was found that soil mixture was not only better than sphagnum moss in respect of rooting and success but even the number of roots per layer was singnificantly better in this case (Table I).

TABLE I

Effect of media on rooting, success and number of roots per layer.

Media	Per cent rooted	Per cent success	Number of roots per layer
Sphagnum moss	40.4	39.2	2.58
Soil mixture	56.7	52.1	3.86
C.D. at 1%	10.2	11.5	1.20

There was marked difference in the effect of the two plant regulators on success, rooting and number of roots per layer. The results obtained with IBA were almost twice of those with NAA (Table II). The superiority of the former over the latter is thus quite obvious.

TABLE II

Effect of plant regulators on rooting, success and number of roots per layer

Plant regulators	Per cent rooted	Per cent success	Number of roots per layer
NAA	28.7	28.7	1.54
IBA	51.8	50.0	3.31
C.D. at 1%	12.5	14.0	1.46

The results obtained with the three concentrations of plant regulators are given in table III. It was very interesting to find that when the two plant regulators were considered together, there was a retarding effect with an increase in their concentrations when compared to control which gave the best results. At the highest concentration of 2 per cent the success was reduced to even less than half.

TABLE III

Effect of concentrations on rooting, success and number of roots per layer.

Concentrations	per cent rooted	per cent success	Number of roots per layer
Control	65.0	58.1	4.81
1 per cent	51.2	49.4	3.24
2 per cent	29.4	29.4	1.63
C. D. at 5%	—	10.7	1.12
C. D. at 1%	12.5	14.0	1.46

The highest percentage of success (72.5) was obtain d when no plant regulator was used and the rooting medium was soil mixture (Table IV). When 1 per cent IBA was used with this medium the success was slightly reduced but with other concentrations of both the plant regulators it was markedly reduced to less than half. In the case of moss the best result of 65 per cent was obtained when layers were treated with 1 per cent IBA. This was far superior to other concentrations of both the plant regulators including control.

TABLE IV

Effect of the interaction among media, plant regulators and their concentrations on the percentage of success.

Treatments	Moss			Soil mixture		
	Control	1%	2%	Control	1%	2%
NAA	43.7	27.5	25.0	72.5	37.5	25.0
IBA		65.0	30.0		67.5	37.5
Not significant						

DISCUSSION

For some years now sphagnum moss is being used as rooting medium in air layering of many plants. Its use along with the polythene film as wrapper has given encouraging results in mango also (3). The comparison of moss with the soil mixture in the present experiment has clearly brought out the superiority of the latter over the former. This not only increased the percentage of rooted layer but also enabled them to produce more roots. The difference between the effects of two media may be because of maintenance of more uniform humidity and better microclimate along with a closer contract with the rooting surface in case of soil mixture.

When soil mixture was used, application of plant regulators could not improve the result over control, while the layers benefitted considerably by this treatmen

when moss was used as rooting medium. This is probably because the soil mixture provided the layers with some sort of rooting stimulus which the sphagnum moss failed to supply.

Layers were found to respond more favourably to the treatments with IBA than NAA. Working with the stem cuttings of Rhod Island Greening variety of apple Hitchcock and Zimmerman (4) reported similar results. 100 per cent rooting was obtained by treating the cuttings with 8000 ppm of IBA in talc ; whereas, the rooting was only 25 per cent when NAA was used.

SUMMARY

An experiment to study the effects of rooting media and different concentrations of NAA and IBA on air layering of Bombay Green variety of mango is described.

Soil mixture consisting of 1 part clay and 1 part sieved leafmould by volume was found to be a much better rooting medium than sphagnum moss. The best result of 72.5 per cent rooting and survival was obtained with this medium without any treatment with plant regulator. When sphagnum moss was used as a rooting medium, treatment of layers with 1 per cent IBA gave the best success of 65 per cent which was far better than all other concentrations including control. Of the two plant regulators IBA was found to be superior to NAA in all respects.

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A STUDY ON THE CHEMICAL COMPOSITION OF PARA-GRASS (PANICUM BRABINODE) AT DIFFERENT STAGES OF MATURITY.

I J. Jauhar, G.S Singh and S. N. Singh

Our present day cattle are in a deplorable condition. Due to stunted growth, long calving intervals, irregular breeding, poor production and susceptibility to various diseases, they have apparently become a liability rather than a national asset.

Although in the first and second Five year Plans, the Planning Commission laid a great stress for the development of Animal Husbandry, particularly on the breeding side, but the production achievements remained far below the target. It indicates that breeding alone can not ameliorate the condition. The induced inherent potentialities through better breeding can not be exploited to their maximum until and unless proper feeding of the animal is done.

In our country the fodder supply is short by 62 and concentrate by 65 per cent (Gullickson, 1958). In terms of digestible nutrients, the situation is even worse with available protein from all sources which is sufficient for only about 23 per cent and energy feeds enough to provide the requirements for only about 38 per cent of the cattle population. The situation is mainly attributed to the fact that only 4 per cent of the cultivated land is used for forage and fodder production as compared to 25 per cent in England and 60 per cent in United States.

The magnitude of the problem becomes more serious when we consider the quality of the roughages we are using for feeding our livestock. In fact for formulating an economic balanced ration, the practical solution lies in growing the nutritious forage crops and grasses. Among the many existing grasses, para-grass (Panicum brabinode) has proved to be a promising one. It is being propagated on a large scale successfully at many dairy farms such as Aarey Milk Colony, Bombay ; Haringhata Farm, Calcutta and Military Dairy Farms etc. The study on its chemical composition and nutritive value at one particular stage has been done at Bangalore (Sen, 1957), but it is an admitted fact that the nutritive value of a particular grass fluctuates with the variation in its chemical composition at different stages of its growth. It was, therefore, planned to study its chemical composition at different stages of maturity, which will serve as an indicator of the corresponding nutritive values.

EXPERIMENTAL

Four main plots each of 18′ × 12′, one at each corner of the para-grass field at B. R. College, Khandari Farm, Agra, were marked out. Each main plot was divided into 24 sub-plots (3′X3′). The samples at a particular stage were collected at random from 4 sub-plots of each main plot. Thus, four representative samples were obtained at every stage of growth. The first cut was taken on the 9th September and the subsequent cuts at fortnightly intervals. Thus, the composition of para-grass was studied at six stages of growth as given below :—

(1) I– At the age of 40 days.
(2) II– ,, ,, ,, ,, 55 ,,
(3) III– ,, ,, ,, ,, 70 ,,
(4) IV– ,, ,, ,, ,, 85 ,,
(5) V– ,, ,, ,, ,, 100 ,,
(6) VI– ,, ,, ,, ,, 115 ,,

The samples were collected by cutting the grass with sickle as close to the ground as possible. The dust was removed by shaking the plants. The samples were immediately taken to the laboratory. All the four samples of the green para-grass were finally chopped and representative parts of each sample were taken.

The proximate principles were determined by the procedure laid down in the A. O. A. C (1955) and the minerals by the modified methods described by Talapatra, Ray and Sen (1940).

RESULTS & DISCUSSION

(A) Chemical composition of para-grass at different stages of its growth.

1. Organic matter content of the grass.

The contents of the crude protein, ether-extract, crude fibre and nitrogen-free–extract were estimated in the grass at different stages of its growth and have been recorded in table I.

TABLE I

The organic matter components of the para-grass at different stages of its growth (per cent on dry matter basis)

Stages	Age in days	Crude Protein	Ether extract	Crude fibre	Nitrogen-free-extract	Total Carbohydrates
I	40	9.31	2.12	29.01	48 61	77.63
II	55	8.93	1.90	29.11	49.11	78.22
III	70	8.78	1.70	29.84	49.73	79.57
IV	85	8.65	1.43	30.56	49.57	80 13
V	100	8.54	1.15	31.40	48.64	80.04
VI	115	8.18	1.29	33.28	46.73	80.01
Average		8.73	1.60	30.53	48.73	79.26

The examination of the data presented in table I indicates that with the progressive maturity of the plant, crude protein content decreases inversely with the fibre. The highest percentage of crude protein is 9.3 and the lowest 8.18 at 40 and 115 days respectively.

The value of the ether extract virtually decreases with the progressive growth. The high percentage of ether extract has been obtained in the first cut and the lowest in the 5th, which is followed by a slight increase in the last cut. This increase may be due to the formation of seed which is generally rich in oil (Srivastava, 1950 and Talapatra, 1957). Crude fibre values vary from 29.0 to 33.3 per cent between the first and the last cuts.

The increasing trend of the nitrogen-free-extract is only upto the third cut and later on a decrease sets in. It shows that the soluble carbohydrates decrease in the grass after about 2½ months of its age. The trend of variation is however contrary to the findings of other workers (Watson, 1951 and Lander, 1942) and needs further confirmation.

The total carbohydrates increase progressively with a slight decrease in the last stage. The values vary from 77.6 to 80.0 percent between the first and the last cuts.

A similar trend for the above nutrients except nitrogen-free-extract has been observed by Lakke Gowda (1953 and 1954) in Jowar, by Mathur and Ray (1943) in Star grass, by Iyer (1935) in Jowar hay, by Lander (Loc.cit.) in Punjab grasses, by Narindra Nath (1953) in some of the perennial grasses and by Talapatra (1949) in the aquatic Assam grasses.

2. Mineral matter content of the para-grass at different stages of its growth.

The total ash, calcium (Ca) and phosphorus (P) contents of the paragrass, were determined at all the stages of its growth and the results have been recorded in Table II.

TABLE II

The progressive ash, calcium and phosphorus contents of the para-grass (percent on dry matter basis.)

Stages	Age in days	Total Ash	Calcium (Ca)	Phosphorus (P)	Ca/P
I	40	10.95	0.53	0.38	1.41
II	55	10.95	0.50	0.35	1.42
III	70	9.95	0.45	0.34	1.37
IV	85	9.79	0.44	0.34	1.31
V	100	10.27	0.48	0.35	1.38
VI	115	10.52	0.49	0.35	1.33
Average	-	10.41	0.48	0.35	1.37

The data in table II show that the total ash, calcium and phosphorus contents of the grass are also influenced by progressive maturity. The mineral constituents decrease till the grass is 85 days old. Later on, they slightly increase, except phosphorus which remains more or less constant. In the case of total ash, similar trend has been obtained by Lakke Gowda (Loc. cit) in the Kaki variety of Jowar.

It is seen that besides the significance of calcium and phosphorus separately, a consideration of calcium and phosphorus ratio is of a very great practical importance in animal nutrition. It will be seen that Ca : P ratio is not appreciably affected by the growth stages. The trend is somewhat erratic which is due to variation in the corresponding values of calcium and phosphorus. The highest ratio is 1 : 1.42 at the age of 55 days and the lowest 1 : 1.31 at the age of 85 days. These ratios may be considered satisfactory in the light of the recommendations of Maynard (1956) according to whom a Ca:P ratio of 1:2 or 2:1 should work well.

(B) Calculated Nutritive Value Of The Para-Grass

From the average chemical composition obtained in all the six cuts and the digestibility coefficient figures for the organic nutrients of para-grass (K.C. Sen, 1957) the digestible crude protein, digestible ether extract, digestible carbohydrates and total digestible nutrients are calculated. The estimated values have been recorded in table III along with those of the para grass (Bangalore) and other common forage crops of the country (Sen, 1952 and 1953).

TABLE III

Showing the calculated nutritive value of the para grass along with other forage plants.

Sl. No.	Name of the fodders.	Digestible nutrients per 100 lbs. dry matter.				Digestible nutrients per 100 lbs. raw material*	
		D.C.P. lb.	Dig. Carb. lb.	Dig E.E. lb.	T.D.N. lb.	D.C.P. lb.	T.D.N. lb.
1.	Para grass (Agra).	5 90	45.30	1.00	53.45	1.48	13.36
2.	Para grass (Bangalore).	8.11	47.35	1.81	59.54	2.03	14.89
3.	Guinea grass	5.83	58.00	0.56	65.09	1.46	16.27
4.	Elephant grass	3.85	48.54	1.33	55.39	0.96	13.85
5.	Sudan grass	1.57	41.47	0.61	44.41	0.39	11.10
6.	Jowar.	3.44	48.86	0.77	54.03	0.86	13.51

*Raw material containing 25% dry matter.

It is clear from the results (Table III) that the nutritive value of para grass (Agra) is better than that of Elephant grass, Sudan grass and Jowar and may favourably be compared with that of Guinea grass. Para grass is fairly rich in crude protein. There is a difference in the nutritive value of para-grass grown at Agra and that at Bangalore. This difference may probably be assigned to the different chemical composition of the grass grown under different types of soil and cultural practices such as tillage, manuring, irrigation etc.

SOME PRACTICAL CONSIDERATIONS

From the calculated nutritive value of the para grass (Table III), it may be seen that 10 lb. of green grass containing 25% dry matter can provide 0.15 lb. and 1.34 lb. of D. C. P. and T. D. N. respectively. An animal weighing 1000 lb. requires 0.6 lb. and 7.5 lb. D. C. P. and T. D. N. respectively for maintenance only. It shows that 40 lb. green para grass supplying 0.6 lb D. C. P. and 5.4 lb. T. D. N. along with 5 lb. of wheat bhusa can easily maintain a 1000 lb. animal without supplementation with costly concentrates. When no green grass is available, 4 lb. concentrate mixture containing 15% D.C. P. will have to be provided along with the wheat bhusa to meet the maintenance requirement The latter will involve an expenditure of 52 nP. considering the cost of concentrate mixture @ Rs. 10.00 per maund against 27 nP. for 40 lb. of green grass, whose cost of cultivation comes to 0.54 nP. per maund only. It is clear from the foregoing statement that the animals can easily be maintained on half the price by growing this grass with the added advantage of carotene which has to be supplied separately when bhusa and concentrates form the only components of the maintenance ration.

SUMMARY

Para-grass is one of the important grasses of India. In fact the grass occupies a very important place in the cattle feeds of the country. There is a huge shortage of nutrients to meet up even the minimum needs of our livestock. The economic-balanced-ration can be formulated by growing the nutritious forage crops and grasses. With a view to study the nutritive value of para-grass at different stages of its growth, the chemical composition of the grass in the first instance was determined.

Samples at progressive stages were taken from the paragrass field at B. R. College, Khandari Farm, Agra and analysed for different ingredients. At each stage of growth, four samples were obtained and chopped separately into small pieces. After that, the samples were dried, ground, powdered and then analysed for proximate principals.

With the progressive maturity of the plant, crude protein decreases inversally with the fibre content. The highest percentage was 9 3 and the lowest 8.1 at the age of 40 and 115 days respectively.

The value of the ether extract virtually decreases with the progressive maturity of the plant but there is a slight increase in the last cut. The crude fibre values vary from 29.0 to 33.2 percent at different stages of its growth.

The highest percentage (49.57) of nitrogen-free-extract was noticed at the age of 85 days and the lowest (46.73) at 115 days, the last stage of its growth in the present study.

The total carbohydrates varied between 77.63 and 80.13 per cent.

The total ash, calcium and phosphorus virtually decrease with the maturity of the plant. The highest calcium (0.5 per cent) was noticed at the age of 40 days and the lowest (0.44 percent) at the age of 85 days.

The calcium and phosphorus ratio was appreciably affected by the maturity. It varies between the range of 1.31 and 1.42 without any systematic trend.

The nutritive value of paragrass (Agra) is better than that of elephant grass, sudan grass and jowar and may favourably be compared with that of guinea grass. D. C. P. and T. D. N. of the paragrass were calculated to be 5. 9 and 53.45 lb. per 100 lb. dry stuff respectively.

It may be seen from the foregoing study that animals can be maintained on half the price by growing this grass with an added advantage of carotene which has to be supplemented when bhusa and concentrate mixture are the only components of the ration.

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FARM EMPLOYMENT

S. N. Kulshrestha

Introduction :—

Under-developed countries like India have been described as vast reservoirs of unutilized and under-utilized human resources. Problem of employment of man-power in these economies have been a baffling solution. The problem of employment specially on farms is that of seasonality of getting work, because of the peculiar nature of the Industry. Apart from the seasonal nature, the capacity of the Industry to provide employment to the existing population is very low, which results in disguised under-employment.

Scope and method of study

The present paper is based on a research project conducted in the Bichpuri village in Agra district. Number of cases investigated were 30. Cases were divided into 4 groups on the basis of the size of the farms. Method of study was direct approach method of field Investigations.

The term 'Farm employment' includes the amount of work opportunities which a farmer gets from his farm by cultivation of crops from bullocks and milch cattle, and also from some allied subsidiary non-farm occupations.

Extent of employment on different sizes of farms

Generally speaking, bigger farms are said to provide more employment than smaller farms as shown in the following table :—

Table Showing Extent of Employment

S. No.	Size of farm (Acres)	Mandays available	Mandays employed*	Mandays idle	% of idle days	Per worker employment
A	2.5-5·0	876.0	310.3	565.7	64.6%	129
B	5-10	985.5	412.0	573.5	58.7%	152
C	10-15	1168.0	635.6	532.4	45.6%	198
D	15 and above	1642.5	879.9	762.6	46.4%	195
	Average	1168	558.6	609.4	52.1%	174

*Mandays available are found out by multiplying the no. of workers by 365 days.

The figures given in the above table reveal that smaller farms provide shorter employment either in terms of percentage of mandays to total days available or per worker employment. Both the measures are higher on bigger farms, in comparison to smaller ones. Per worker employment is lowest in the group A being of 129 days, and increasing up to 198 days in group C. The percentage of idle days to total days available are higher in group A being 65%. On an average farmers are found to be employed only on 174 days which are 52% of man days available.

Sources of employment

Major sources of employment are divided into farm employment sources, which include employment from cultivation of crops, maintenance of bullocks and milch cattle, and non-farm sources which include employment from subsidiary occupations. The following table shows the extent of employment provided by these different sources.

Table showing employment from different sources

S. No.	Size group	Employment on farm (Man-days)				Non-farm employment (Mandays)	Total Emp. (M. D.)	% of farm Emp. to total.
		Crops	Bullocks	Milch cattle	Total			
A	2.5-5.0	148.0	44.2	44.1	236.3	74.0	310.3	78.7%
B	5-10	280.5	59.6	43.2	383.3	28.7	412.0	92.9%
C	10-15	385.7	93.7	91.8	572.2	63.4	635.6	86.6%
D	above 15.	593.6	148.4	125.4	867.4	12.5	879.9	99.1%
	Average	351.2	86.5	76.4	514.1	44.5	558.6	89.2%

As stated above, the farms having larger size provide more employment in comparsion to smaller farms. On smaller farms employment from Crops is of 148 man days* while on larger farms it is of 593.6 mandays, and is showing a regular increasing trend. Employments from bullocks and milch cattle are also showing an increase on larger farms, because, on smaller farms less No. of bullocks and milch cattle are maintained, as they require certain capital expenditures.

On the other side non-farm employment is higher on smaller farms (with the exception in the second group in which very few farmers had any other occupation to do and as a result the average went down) and comparatively lower on larger farms. It is because of the fact that on larger farm the farmer gets sufficient employment from the land and milch cattle and he has very less time left to carry any subsidiary occupation and thus proportion of non-farm employment is lower in larger farm-size groups.

*A man-day is when a farmer works either continuously or in breaks for eight hours.

Extent of family labour

Indian farms can mostly be regarded as family farms. The main supply of labour for cultivation is from the family (strictly of the households) of the cultivator. There are many farms on which family labour is much insufficient and permanent hired labour has to be employed, while on some farms casual labour only in case of timely operations like sowing and harvesting, is sufficient, as shown in the following table :—

Table showing proportion of family labour and hired labour

S. No.	Size group (Acres)	employment on Crops			percentage to total labour	
		family	hired	Total	family labour	hired labour
A	2.5-5	148.0	20.7	168.7	87.1%	12.9%
B	5-10	280.5	74 9	355.4	79.5%	20.5%
C	10.15	385.7	186 6	572.3	68 7%	31.3%
D	Above 15	593.6	456.1	1049.7	56.5%	43.5%
	Average	369.2	184.6	553.8	72.9%	27:1%

From the figures given in the above table it is quite clear that the employment of hired labour is mainly on larger farms. On smaller groups it is very insignificant, being only 13% to total, while on larger group it is near about half of the total. On larger farm, the reason for such a high requirement of hired labour is that on these farms, No. of workers per acre are less or in other words, labour is proportionately lesser than land, which has to be supplemented from hired labour.

Measures to increase employment potential

Thus, from the last discussion we see that on an average there is an unemloyment of 174 days per worker in a year which is about 48% of the total days available. This percentage is quiet high, and requires special consideration to be decreased. There may be 2 different sets of conditions in which suggestions for increasing employment may be dealt ; being :—

1. When labour is idle and land is idle.
2. When labour is idle but land is engaged.

Under the first set of conditions following measures can be suggested :—

1. Increasing the farm size business

Farm size business can be increased either by increasing the size of farm, which is near about impracticable under Indian conditions, or by increasing the intensity of cropping. Farm size business may also be increased, by growing of intensive crops like sugarcane, potato, and other vegetables.

2. Adding more work on the farm

New, extra work can also be made available by introducing certain operations like bunding of fields, making irrigation and drainage channels, levelling etc. Introduction of improved techniques of production have also proved satisfactory in this direction. Such techniques may be top-dressing of wheat, hoeing with Akola hoe, ridge sowing in potato and the like.

For the second set of condition, the following recommendations can be made :—

1. Starting of new non-farm jobs:—Like the subsidiary occupations, agricultural processing or agro-industries. Such industries may be rope making, basket making, weaving and spinning, oil pressing, gur and sweet making, preservation of fruits and vegetables and the like.

2. Shifting of the surplus labour to the centres of industrial, minning, irrigation and power projects, and other development centres. But this method is not possible, until carried on at the National level as it requires very planned action.

In short it is the nature of employment of farmers, its extent and that of idleness and some methods to tackle it.

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STUDIES ON THE HABITS OF COMMON YELLOW WASP-POLISTES HEBRAEUS FABR.

PART II

R. D. Saksena.

The foregoing lines deal with important habits of these wasps and show interesting organisation of their society.

Phenology :—

The foraging wasps, mostly found on wings, belong to the worker class. They are females, having atrophied reproductive organs although in several species of wasps they can be made to function as generative females by being fed on special food. It is doubtful, if this phenomenon occurs in *Polistes hebraeus*. Some authors have claimed that the maturity of sex organs in a larva depends upon the quality of food and in favourable seasons, the worker-larvae, in consequence of a generous diet, become fertile and adults developed from such larvae, lay eggs parthenogenetically producing drones only.

The workers and the generative females very closely resemble each other and sometimes it is very difficult to indentify a worker from a queen by its size, because well developed gonads have been found in both large and small sized females. Bischoff has noticed polygyny in several species of Polistes, e.g., *P. marginalis*; Ihering has observed monogyny in the South American species of *Polistes*; but Polygyny also occurs occasionally as an abnormal feature. In the common yellow wasp Polygyny occurs although the author holds that favourable conditions encourage monogyny, in order to form a better organisation of the society but in trying circumstances Polygyny takes place to preserve the race and to save it from extinction. It is worthy of notice that the sexually-mature individuals are produced at a particular time of the year and under certain circumstances. This corroborates the fact that the periodicity in the production of sexual individuals depends upon environmental conditions. It is likely that the production of sexual individuals preserves the reproductive potentiality as found in other animals.

The sexual forms are produced generally from the brood which hatches out in September. The reproductive organs are mostly mature by this time. The males

or the drones lurk about in crevices and holes in walls and in articles of furniture in quest of females. The workers are gradually reduced in number with the approach of winter till in November not a single one can be seen. The females too are not met with in good numbers although males are very commonly seen flying about. The work of the nest is also reduced after the emergence of the last brood as no eggs are further laid; consequently, there is a heavy mortality of the workers. The newly emerged sexually-mature females are pounced upon by the males and copulation starts immediately. The males these days are very vicious so much so that no sooner a female emerges, she is caught hold of by them. They even fight among themselves for the possession of a female. This is because the number of females is extremely low and the chances of individual mating for every male are very rare. Mating does not take place in the nest, but elsewhere because by October all males have left the nest and the females also leave sometime afterwards. The males have a partially gregarious habit.

Generally during winters, viz. December and January, only males are to be seen and the females hibernate. Normally the females start their work late in February or in the first week of March. The males by now have totally disappeared and the establishment of a new colony is the sole responsibility of the queen. The first brood is that of workers which assist the queen in building the nest. Later on, sexual forms are produced in subsequent broods and in very small numbers. After that the queen never leaves the nest. The newly emerged wasps stay in the nest for about a day before going out. They then bring wood-pulp and partially crushed insects for the larval-food. As the number of workers increase, a few always remain at home to meet field workers and to relieve them of their loads. Rarely field workers themselves feed the grubs. April, May and June are the months of greatest activity when the workers enlarge the nest and the queen deposits fresh eggs as soon as the cells have been vacated. Males do not go foraging, but generally stay in the nest or in crevices. From the last week of August to the end of September, males emerge in large numbers and by October all of them leave the nest; the workers are dead; females produced commence nuptial activities, which over the nest have totally ceased. The males do not live for very long after copulation and the females hibernate. Activity again commences in February when new colonization begins. The cold weather either destroys the inhabitants or so reduces their vitality as to make it impossible for them to procure their subsistence and ultimately they die due to adverse conditions, but the females live and bridge over the unfavourable period taking complete rest. According to Sharp, colonies would be permanent in places where there is no cold season. But De Saussure observes that the colonies die off annually and new nests are established every year. He further believes that the combs are abandoned for no apparent reason and lowering of temperature or scarcity of food are not the determining factors but heavy mortality in winter is apparently a physio-logical necessity, which can explain the seasonal appearance and heavy

mortality at certain times of the year occurring in equatorial regions which are not subjected to great variations of temperature. The open nest of *Polistes* do not exhibit very wide differences of temperature throughout the year. Ihring confirms this view that summer communities and hibernating fertilised females lasting for an year occur in an American species of *Polistes*.

Behaviour

Despite their terrifying attitude wasps do not sting and they can easily be watched at work from very close quarters if all disturbing movements near the nest are avoided. But on slightest provocation they fly at the intruder and sting the victim, just at the touch of their abdomen. Very often they fly overhead from where they dive down on the stranger's body and sting him. Sometimes they chase the intruder upto a distance of 50 yards or so.

The poison injected in stinging mainly consists of the secretion of the acid gland while the secretion of the alkaline gland is useful in neutralising the little acid which remains within the sting-sheath after the poison has been injected into the victim's body. It can be easily neutralised by any alkali specially ammonium hydroxide. Quinine hydrochloride has also been recommended for external use. Rubbing volatile liquids, e.g., spirit and ether also gives a considerable relief. The sting causes a sudden burning sensation and extreme pain, which continues for about an hour, after which the area round the point of sting is benumbed and greatly inflamed. After about 12 hours, an itching sensation starts and the swelling gradually subsides. The poison has a very depressing effect and may cause extreme weakness. In about three days, the inflammation completely subsides but it takes about a week to restore normal condition. Very seldom apainful sting may form a wound which may leave a big scar.

The workers and the females are capable of stinging while the males are harmless. They may sting several victims one after another but the subsequent stings are not so painful, apparently due to lesser amount of poison being injected. Unlike honey-bees, the sting is not detached from the body to be retained in the victim, but it is instantly withdrawn because it is controlled by powerful muscles.

Wasps are very obstinate and it is difficult to exterminate them if once they have made a normal sized nest. Any amount of damage to the nest does not discourage the wasps and they make the necessary repairs as quickly as possible. Smoking at night is helpful in driving them away, but they come back soon after.

Horne has suggested the introduction of Paroah's ant—'*Oecophylla smaragdina*' which have a great antipathy to them, into their comb. These ants are fond of feeding on the unprotected juicy larvae of the wasps.

Wasps are positively phototropic but prefer darkness for repose.

They have an extremely wonderful memory for the location of their combs. Generally they have a fixed route to their nest which depends on local surroundings, hence any change in the environments confuses them. When placed in cages, whose openings are covered over by cloth, they easily nibble a small hole in it and escape. In many social wasps the nest is guarded by special individuals who either sit on the nest or lurk near about, with their mandibles wide-open, wings obliquely spread out and joints of legs held at right angles to each other ready to give warning to all the members of the colony by noisy wing vibrations.

Although their social structure hardly permits any philanthrophy, yet it is remarkable that Hess observed an orphan brood being cared for by different queens when the stem mother had accidentally died.

The wasps keep their mandibles, maxillary and labial palps, and antennae scrupulously clean by means of the toilet apparatus located in the front pair of legs. Another very prominent toilet apparatus is found on the hind legs for cleaning wings, thorax and abdomen. Even legs are passed through the brushes of the toilet apparatus for cleaning them.

Although the organisation of the community and the division of labour are so efficient as to minimise the possibility of a clash, yet wasps have been observed to fight among themselves. The cause of the combat could not be determined. During one of such combat the author noticed that the stronger wasp caught hold of the struggling weaker one in between the legs and started biting it by the mandibles. The legs were cleanly bitten off ; pieces from mesothoracic and metathoracic terga were cut away in a number of places ; the cervix of the left side was cracked on the area of the ocelli : the first maxillary palp of the right side was totally pulled out, besides three tarsi of the left front leg and four of the left middle and the same number of the hind one were detached. The stronger wasp received only minor injuries The fight continued for about thirteen minutes. The stronger finally got an opportunity of stinging the weaker one in the posterior most intersegmental membrane. This resulted in the instantaneous paralysis of the victim which expired soon after. Immediately after stinging, the assailant flew away leaving the victim to its fate.

The wasps are very tenacious insects and can resist even major injuries. Horne had noticed that a decapitated wasp can live for more than three hours and perform the various functions for some time. It could live for even six hours when half of the abdomen was severed. It could even resist hydrocyanic acid for an hour or so. The movements of tarsi continued for over half an hour.

Wasps can also fight against weather conditions. No heat is too great for them ; hence, they are found in warm regions, i.e., in the torrid and temperate zones. Cold weather destroys a major population of the nest or reduces vitality, that is why

sexual forms are specially produced at the approach of such time. During spring the atmospheric conditions suit them best when plenty of cellulose and sugar in the form of nectar are available to them. The insects can manage to starve for over three days and may live still longer if a constant supply of water is available to them. There is plenty of fat in the body cavity lining the various sclerites and in between the organs. It supplies sufficient energy to the insect for a good length of time. The life is cut short if water is not available ; hence generally we find the yellow wasps clustering near water-tanks, wells, water channels or similar other places.

Food

The food of the insect consists mainly of saccharose, which is collected from flowers or other places The workers constantly visit the field for this purpose. A full nest of wasps could be maintained for over 6 months on molasses, crystalised sugar, honey, candy, raisins and other sweet fruits. They are very fond of sugar in any form but specially prefer raisins and can live on this food only for a very long time.

Wasps feed upon other plant-products also, besides the animal food which consists of spiders, caterpillars, and dead insects. In nature animal-food is usually supplied to the grubs, although they can subsist on sugar solution only. David Sharp states that the larvae are first given saccharine matter procured from flowers and fruits, but later on a stronger diet of insect-meat is supplied. For this, various kinds of living insects are chased, stung and paralysed. They are then chewed up to succulent pieces by means of mandibles and given to the larvae which receive them by stretching out their heads. Under extreme conditions, cannibalism among these insects has also been noticed. The stronger insects devour the larvae, pupae and even the weak adults. They have been noticed even to have gone to the length of eating the dead bodies of their own companions under famine conditions. Nibbling of the comb as a measure of last resort has also been noticed.

The chewing of wood from posts, poles, articles of furniture or dry twigs simply serves in collecting pulp for the manufacture of paper for the nest. This is not eaten, but chewed and converted into pulp within the salivarium of the insect. Besides wood, they also use waste paper for this purpose. The various materials used in nest-making are responsible for the appearance of striations on the walls of the cells and also variation in colours therein.

Economic Importance

The wasps are regarded as unmitigated nuisance. As they live in association with human dwellings, they are generally a source of annoyance. They are not very serious as crop pests, although it has been recorded that they nibble at various plants.

When fruits are ripe, they often cause serious damage specially to the sweet ones. Vineyards are the regular haunts of these insects, and they cause serious damage to grapes. Like other insects, they may act as carriers of various plant and animal diseases. They are not definitely known to carry germs of any particular disease, but their legs and body may be contaminated with spores of bacteria, fungi and protozoan organisms and thus they may act as carriers. They cause more annoyance than damage.

Wasps are useful friends because they destroy a large number of caterpillars, green and black flies and other harmful insects. The spiders and their eggs are also picked up by the wasps and given to their grubs. They are good scavengers and they easily strip the bones of dead animals of their skin and flesh. As pollinators their value is in no way less than most of the insects.

Natural Enemies

The wasps are heavily infected by *stylops*. These parasites often occupy the whole of the abdominal cavity so that it often becomes difficult for the victim to carry out the normal functions of life. Generally there is a single spacimen of the stylops occupying the last three or four abdominal segments ; but in several wasps even two have been noticed. Horne has recorded three, while Bischoff has drawn attention to a very rare case of a maximum number of fifteen in the abdomen of *Polistes annularis* Linn. The female wasps alone have been found to be parasitised. The parasites too were mostly female *stylops*. The cocoons of *Polistes* have been recorded to be liable to *Crypturus* infection.

The nest of these wasps is found to possess eggs of *Pegomya inanis*, and maggots of *Volucella inanis*. A thread-worm has been recorded by Kristof, while a beetle, *Rhipiphorus paradoxus* has also been found to be a parasite on the wasp larvae.

Summary

1. Polistes resort to polygyny under abnormal conditions of life only, although monogyny is the common practice.

2. Workers perish by November probably due to physiological necessity. Drones emerge in September and leave the nest by the following month. Activity in the nest revives late in Ferbruary or early in March, and it is at its climax in May and June.

3. Wasps sting on slightest provocation and use a variety of tactics in doing so. They are extremely vindictive and even cannibals under extreme famine conditions.

4. These insects have a wonderful sense of location, direction and an unfailing memory.

5. Wasps feed on animal matter and sugar but scrape wood or plants to prepare pulp for the comb.

Acknowledgment

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CHAETOTAXY OF THE MATURE LARVA OF *Acherontia styx* West. (LEP : SPHINGIDAE)

G. P. Mukerji.

Contents

1. Introduction
2. Technique
3. Chaetotaxy
   (i) General
   (ii) Head
   (iii) Thorax
   (iv) Abdomen
4. Summary
5. Table
6. Acknowledgments
7. References
8. Plates
9. Abbreviations

Introduction.

This paper deals with a complete description of the setae present on the body of the larva of *Acherontia styx* West, Gardner ('38, '41, '42 and '44) ; Sevastopulo ('44, '45 and '48) and Singh ('33) have given morphological description of different Ledidopterous larvae, but chaetotaxy has generally not been dealt with. Often in the larval insects the same seta has received different confused names. In the present work Hinton's nomenculature ('46) has been followed which is mostly employed these days. The two different types of setae in the larva of *A. styx* have been termed by Hinton as pro-prioceptor or microscopic and tactile or long setae. The former commonly located at the anterior margin of the thoracic and abdominal segments are marked by a capital 'M'

Technique.

Mature fifth or final-instar larvae of *Acherontia styx* West. were carefully examined under dissecting microscope or bull-lens. To avoid the erroneous data, conclusion were based on the average of a good number of observations. After studying the preserved specimens the readings were confirmed with the help of the fresh specimen.

Chaetotaxy.

i. General. The final instar larva of *Acherontia styx* West. is a well-built robust, soft skinned caterpillar. It is variously coloured and bears the characteristic

horn on the terminal segment (Plate I, Fig. 2). As compared to the size of the larva the setae are few and small in size.

ii. Head. On the head region the setae are aggregated only in the ocellar region and near the antenna. The rest of the space is devoid of any seta. Ocellar region of the cranium with O_1, O_2, O_3; SO_1 and SO_2 present. Between the ocellar region and the lateral region of the cranium a prominent seta A_1 present (Plate I, Figs. 3, 4 and 5). A_1 is the longest of all the setae in this region and is about thrice as long as O_1.

iii. Thorax. Pro-thorax with MXD_1 ; MV_2 and MV_3 present. Of these the last two are just near the first thoracic leg on the anterior side. Meso-thorax is devoid of setae while the meta thorax bears only a (V_1, Plate II, Fig. 1, T_{1-3}).

iv. Abdomen. The first and second abdominal segments with MD_1; MV_3; SV_1 and V_1 (Plate II, Fig. 1, A_{1-2}). Third to sixth abdominal segment with only MXD_1 and MV_3 (plate II, Fig 1, A_{3-6}). Seventh, eighth and ninth segment with MXD_1; SV_1; V_1 and MV_3 (Plate II, Fig 1, A_{7-9}). Tenth abdominal segment with MV_1 ; V_1 and V_3 (Plate II, Fig. 1, A_{10}).

Besides the above mentioned thoracic setae Hinton 1946) has described the presence of MD_1; MSD_2 ; MV_1 and MV_2 in the meso-thorax and MSD_1, MSD_2 ; MV_1 and MV_2 on the meta-thorax in the first instar larva of Sphingidae. It is, however, interesting to note that none of the seta recorded by him on the meso-and meta-thorax of the first instar larva is present in the last-instar stage.

Summary

Setae present on the final instar larva of *Acherontia styx* West.

1. Ocellar region of the cranium with A_1; O_1, O_2, O_3; SO_1 & SO_2.
2. Prothorax with MXD_1; MV_2 and MV_3.
3. Mesothorax without any seta and metathorax with V_1 only.
4. First two abdominal segments with MD_1; MV_3; SV_1; and V_1
5. Third to sixth abdominal segments with MXD_1 and MV_3.
6. Seventh to ninth segment with MXD_1 ; SV_1 ; V_1 and MV_3.
7. Tenth abdominal segment with MV_3; V_1 and V_3.

Table :—

Table showing the number and position of the setae on the lateral half of the body of the larva along with Hinton's nomenculature.

No.	Region	Seta	Hinton's nomenclature	Total number of the setae (on each lateral half)
1.	Head	Anteriores prima	A_1	1
2.		Ommatalis „	O_1	1
3.		„ secunda	O_2	1
4.		„ tertia	O_3	1
5.		Sub-Ommatalis prima	SO_1	1

6.		Sub-Ommatalis secunda	SO_2	1
7.	Thorax	Microscopic-verticalis secunda	MV_2	1
8.		Microscopic-middorsalis prima	MXD_1	1
9.	Thorax & abdomen	Microscopicverticalis tertia	MV_3	11
10.	Abdomen	Microscopic-dorsalis prima	MD_1	9
11.		Sub-verticalis prima	SV_1	5
12.		Verticalis prima	V_1	7
13.		verticalis secunda	V_2	1
Total number of setae on the lateral half of the body				41

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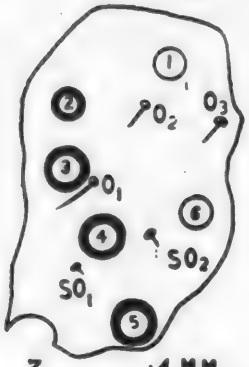
1

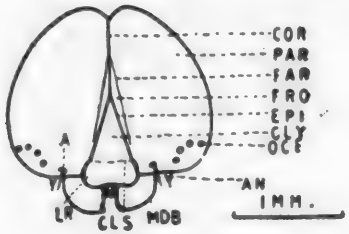
3·5 MM.

2



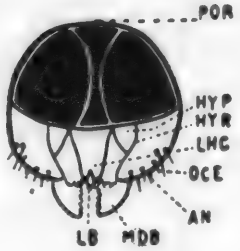
·4 MM.

3

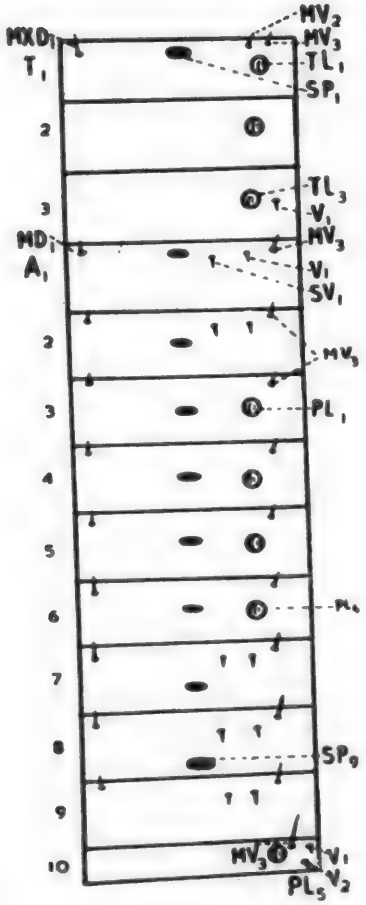


1 MM.

4



5


MXD1
T1
MV2
MV3
TL1
SP1
2
3
TL3
V1
MD1
A1
HV3
V1
SV1
2
HV3
3
PL1
4
5
6
7
8
SP9
9
10
HV3
V1
PL5
V2

Plates and Figures

Plate I

Fig. 1. Mature *Acherontia styx* West. month.
Fig. 2. Final or fifth instar larva.
Fig. 3. Ocellar region of the larva enlarged.
Fig. 4. Head of the larva (Dorsal view)
Fig. 5. Head of the larva (Ventral view)

Plate II

Fig. 1. Diagramatic diagram of the setae present on the lateral half of the body of larva.

Abbreviations

Plate I

1—6 First to sixth ocelli
A_1 Anteriores prima
AN Antenna
CLS Clypeo—labral suture
CLY Clypeus
COR Coronal suture
EPI Epistomal suture
FAR Frontal arms
FRO Frons
HYP Hypostome
HYR Hypostomal ridge
LB Labium
LR Labrum
MDB Mandible
O_1 Ommatalis prima
O_2 Ommatalis secunda
O_3 Ommatalis tertia
OCE Ocelli
PAR Parietals
SO_3 Sub-ommatalis prima
SO_2 Sub-ommatalis secunda

Plate II

A_{1-10} First to tenth abdominal segment
MD_1 Microscopic-dorsalis prima
MV_2 Microscopic-verticalis secunda
MV_3 Microscopic-verticalis tertia
MXD_1 Microspopic-mid-dorsalis prima
PL_1-PL_5 First to fifth pro-leg
SP_1-SP_9 First to ninth spiracle
SV_1 Sub-verticalis prima
T_1-T_3 First to third thoracic segment
V_1 Verticalis prima
V_2 Verticalis secunda

NOTES

A LIST OF THESES SUBMITTED TO THE AGRA UNIVERSITY THROUGH THE B. R. COLLEGE IN 'ANIMAL HUSBANDRY & DAIRYING' (Till 1961)

CLASSIFICATION OF THE THESES

(At post graduate level)

Class No.	Title of the Class	No. of Theses Written
	Dairying	
I	Dairy Bacteriology	3
II	„ Chemistry	42
III	„ Economics	6
IV	„ Technology	30
	Animal Husbandry	
I	Animal Breeding	2
II	„ Embriology	1
III	„ Nutrition	10
IV	„ Physiology	2
	The details of the theses are given in the following tables	

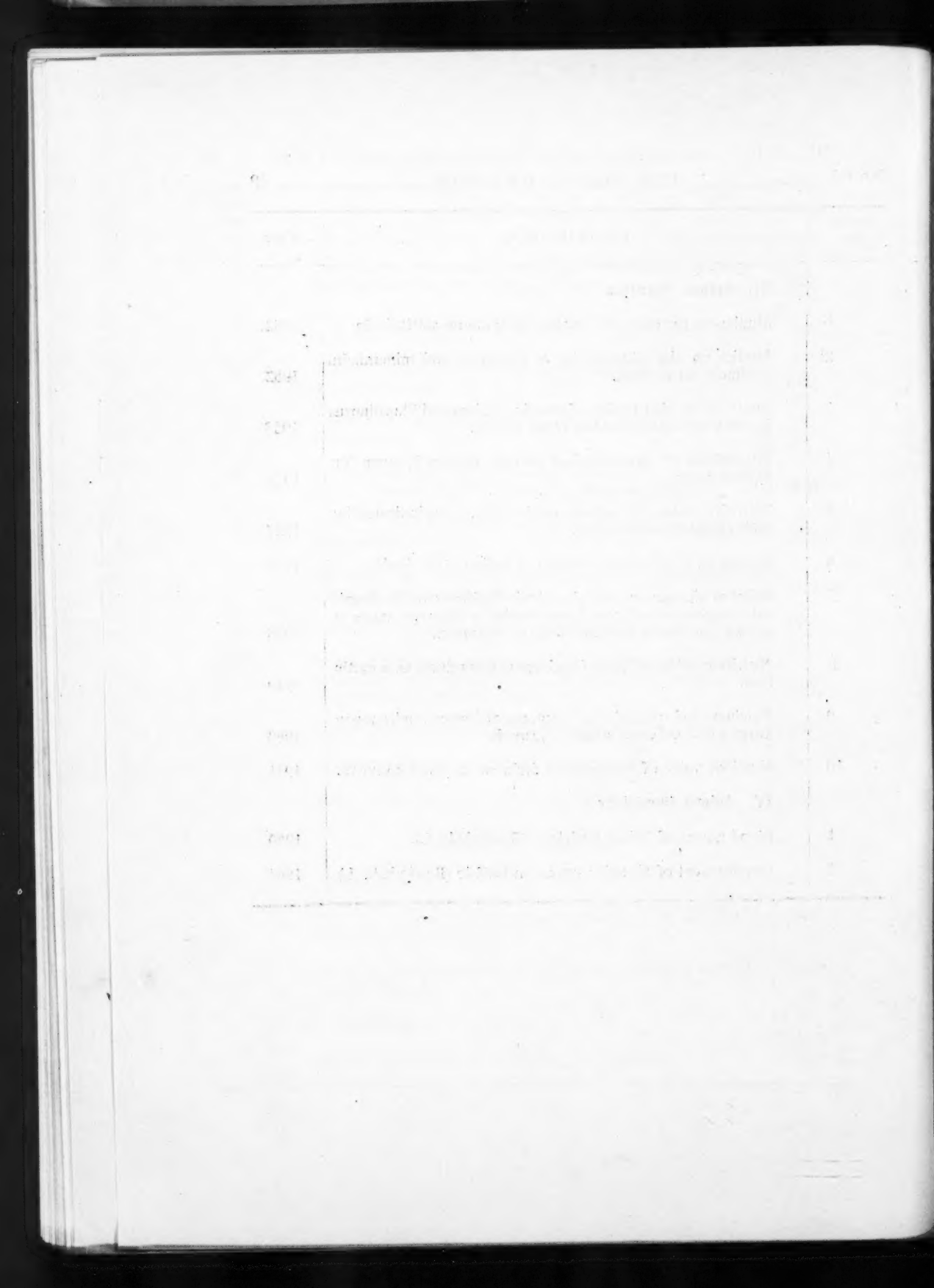
S. No.	Title of the theses	Year
	DAIRYING	
	I Dairy Bacteriology	
1.	Studies on the quality of market milk in Agra City.	1959
2	Bacteriological quality of milk under different sanitary conditions of production.	1960
3	Studies in Bacteriological Quality of milk	1961

Serial No.	Title of the theses	Year
	II Dairy Chemistry	
1	Effect of stage lactation upon general composition of milk.	1951
2	Studies on changes in the Composition of mllk due to different breeds and species.	1951
3	Freezing point as an aid to check adulteration in milk with water.	1951
4	Variations in the Carotene and Vitamin contents of milk.	1951
5	Studies on partition of nitrogen in the milk of different breeds and species.	1952
6	Study of the legal standards of milk in Uttar Pradesh.	1952
7	Stage of lactation : A factor in determining the general composition of milk.	1952
8	Applicatlon of Freezing point in detection of adulteration of milk.	1952
9	Influence of some factors on the composition of milk and milk fat.	1952
10	Validity of Freezing point test in detecting adulteration in milk with water.	1952
11	Variations in the carotene and vitamin. A content of milk.	1952
12	Analytical constants of milk and milk fat as influenced by season and stage of lactation.	1952
13	Variations in the size and distribution of fat globules in milk due to feeds.	1952
14	Studies into the effect of various feeds and heat treatments on general composition of milk.	1953
15	A study on the composition and properties of Colostrum.	1953
16	Carotene and Vitamin A contents of cow.	1953
17	Carotene and Vitamin A contents of cow and buffalo milks as influenced by feeding and various heat treatments.	1953

Serial No.	Title of the theses	Year
18	Progressive changes in chemical composition of milk during souring.	1953
19	Effect of stage of lactation upon general composition of milk.	1953
20	Time and temperature studies on the skin formation and composition of milk.	1953
21	Estimation of T. S. in milk.	1953
22	Effect of certain factors on protein distribution and phosphorous content of cow milk.	1953
23	Variations in milk constituents as influenced by season and the stage of lactation. Part I : Carotene & Vit. A Contents, Part II : Calcium, Phosphorus and iron contents.	1953
24	Effect of different heat treatments on its Carotene and Vit. A contents of cow and buffalo milks.	1954
25	Freezing point as a measure in detection of adulteration of milk with water.	1954
26	Chemical changes during souring of milk.	1955
27	The estimation of total solids in milk.	1955
28	Study of variations in Calcium Phosphorous and iron contents of milk as influenced by the stage of lactation.	1956
29	Inter-relationship between different constituents of milk.	1956
30	Study of different factors effecting the Calcium, Phosphorus and iron contents in milk.	1957
31	Freezing point as an aid to check adulteration in milk with water.	1957
32	A study on the variation in Phospholipid contents of Indian milks.	1957
33	A study on the distribution of fat and fat-globules during coagulation of milk.	1957
34	Influence of season and feed and the stage of lactation on Carotene and vit. A contents of milk.	1957

Serial No.	Title of the theses	Year
35	A study on the variation in phospholipid contents of Colostrum of different species and abnormal milks.	1958
36	Studies on Colostrum.	1959
37	Chemical changes during souring of milk.	1059
38	Studies of fat globules in the milk of different species of animals.	1959
39	Effect of souring on total and dialysable calcium and phosphorus of milk.	1960
40	Effect of different heat treatments on the nitrogen distribution of milk.	1960
41	Inter-relationship between different constituents of milk as influenced by certain factors.	1960
42	Effect of different heat treatments on the nitrogen distribution of milk.	1961
	III Dairy Economics	
1	Relation of daily yield to lactational yield of cattle.	1953
2	The Economics of dairy farming as studied under the present practices.	1954
3	The cost studies for milk production in the eastern part of Hariana tract in the district of Meerut (U. P.)	1955
4	To Work out the most economical unit for production of milk in Gwalior town and suburbs.	1956
5	Cost of raising heifers upto first calving in Meerut District (U. P.)	1957
6	Relation of monthly yield to laictational yield in dairy animals	1960
	IV Dairy Technology	
1	Changes in the composition of butter during cold storage.	1951
2	Studies in ghee.—1 Investigations to test the validity of legal standards. 2. Effect of storage on the analytical contents.	

S. No.	Title of the theses	Year
3	Effect of locality and adulteration on the Physical and Chemical contents of ghee.	1951
4	Studies on methods of manufacture of ghee, Part I. Effect on analytical contents of ghee. Part II, Effect on yield and fat losses at various stages.	1952
5	Keeping quality of Butter under cold storage as influenced by different treatments.	1952
6	Chemical changes in butter and its keeping quality as indicated by score during cold storage.	1952
7	Locality variations in physical and chemical contents of ghee.	1952
8	A study on the distribution of fat and fat-globules in dahi.	1953
9	The effect of various temperature of manufacture and subsequent storage on the physical and chemical contents of ghee.	1953
10	Catalytic effect of certain metals on oxidation changes in relation to oxygen tension in ghee.	1953
11	Keeping quality of ghee from different breeds and species as influenced by metals.	1953
12	Effect of cream ripening on the efficiency of churning and the keeping quality of butter.	1953
13	Effect of heat on the quality of butter fat.	1953
14	Standardization of the conditions for the manufacture of good quality ghee by the creamery butter method.	1954
15	Validity of legal standards of ghee in the light of planned adulteration.	1951
16	Study of certain factors effecting the marketable and keeping quality of khoa.	1955
17	Effect of metallic contamination on the keeping quality of butter.	1955
18	Studies on ghee Part I. to test the validity of legal standards, Part II. to study the storage effect on adulterated ghee.	1955

Serial No.	Title of the theses	Year
19	Time / temperature relationship in the clarification of butter into ghee and its effect during storage.	1955
20	Effect of acidity of curd on the quality of ghee by desi method.	1957
21	Effect of heat on physico-chemical properties of ghee and certain edible oil.	1957
22	Validity of legal standards of ghee in the light of planned adulteration.	1957
23	To study the effect of oxygen concentration on ghee during storage, manufactured by creamery butter method.	1958
24	Effect of metallic contamination on the keeping quality of butter stored at 40° F.	1958
25	Studies on keeping quality and changes in composition of creamery butter during storage.	1958
26	Changes in creamery butter during cold storage.	1959
27	Effect of different temperature/time combinations of stratification and clarification on the keeping quality and vit. 'A' content in ghee during storage.	1960
28	Study on the keeping quality of khoa.	1960
29	Study of the market quality of khoa in Agra City.	1961
30	Study of the quality of table butter in Agra City.	1961
	ANIMAL HUSBANDRY	
	I Animal Breeding	
1	Structural abnormalities of female genitalia and sterility in buffaloes (Bos bubalis L.)	1956
2	Structure and mal-formations of female genitalia in buffalo—(Bos bubalis, L)	1957
	II. Embriology	
1	Prenatal development of *buffalo—Bos bubalis L.*	1961

Serial No.	Title of the theses	Year
	III. Animal Nutrition	
1	Studies on the carotene contents of common cattle feeds.	1952
2	Studies on the distribution of Carotene and minerals in common cattle feeds.	1952
3	Study on the distribution of protein calcium and Phosphorus in some emergency fodders (Tree leaves).	1953
4	Possibilities of substitution of dietary protein by urea for buffalo heifers.	1956
5	Nutritive value of certain cattle fodders as indicated by their chemical composition.	1957
6	Studies on the Carotene content of Indian cattle feeds,	1958
7	Effect of nitrogenous and phosphatic fertilizers on the chemical composition of green jowar fodder at different stages of growth and on its nutritive value at maturity.	1958
8	Nutritive value of Jowar (Andropogon sorghun) as a cattle feed.	1959
9	Calcium and phosphorus contents of Jowar (Andropogon Sorghun) at different stages of growth.	1960
10	Nutritive value of Paragrass at different stages of maturito.	1961
	IV. Animal Physiology	
1	Blood norms of Indian buffaloes (Bos-bubalis L).	1960
2	Development of digestive system in Buffalo (Bos-bubalis L).	1961